

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

United States Non-Provisional Patent Application

for

**MINING DRILL STEELS**

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## **Mining Drill Steels**

### **CROSS-REFERENCE TO RELATED APPLICATIONS**

#### RELATED APPLICATION

5           This application is a continuation of co-pending and co-owned U.S. Patent Application Serial No. 09/668,186, filed with the U.S. Patent and Trademark Office on September 22, 2000, by the inventors herein; which is a division of U.S. Patent Application Serial No. 09/124,780, now U.S. Patent 6,533,049 entitled "*Mining Drill Steels and Methods of Making the Same*", filed with the U.S. Patent and Trademark Office on July 30, 2001, by the inventors herein; which is a  
10 continuation-in-part of U.S. Patent Application Serial No. 08/917,623, now U.S. Patent 6,516,904 entitled "*Mining Drill Steels and Methods of Making the Same*", filed with the U.S. Patent and Trademark Office on July 23, 1997, by the inventors herein, the specifications of which are incorporated herein by reference in their entirety.

### **BACKGROUND OF THE INVENTION**

#### 15   FIELD OF THE INVENTION

The invention disclosed herein relates generally to alloy steels used in drilling operations, more specifically it relates to steel drills normally used for roof bolt operations.

#### BACKGROUND OF THE PRIOR ART

For a number of years mining, particularly coal mining, has been carried out by securing  
20 protective plates to the roof of a mineshaft as it is advanced through the earth. Such plates protect the shaft and most importantly protect the miners against a collapse of, or falling of debris from, the roof of the shaft. To secure such protective plates to the mine roof, holes are

drilled in the roof. Bolts anchored in the roof secure the protective plates. The bolts may be embedded in resin forced into the hole drilled in the roof or the bolt may be designed to expand to grip in the hole.

In order to drill holes in the rock strata, a conventional roof-drilling machine is utilized.

5 Typically, these drilling machines include a drive end and utilize drill steel members and a carbide insert or drill bit, generally 1" in diameter, attached to one end of the final drill steel member to drill the holes in the mine roof. These drill steel members are generally coupled on the other end, e.g. the drive end, by a chuck located on the drilling machine. This attachment provides a means for rotating the drill member and thus the drill bit to remove material and  
10 debris from the drilled hole.

To facilitate the removal of material and debris from the drilled hole, many drilling machines incorporate a vacuum suction collection system wherein the drill steel member is constructed from a hollow steel bar. Connected to the drill bit are one or more lengths of drill steel formed as hollow tubes of a suitable steel material. Such tube, or varying lengths of it, is  
15 connected ultimately to the rotating chuck of a drill motor. The chuck itself is connected to a vacuum to draw the dust from the drill bit through the drill tubes into a collector. In this way, the air in the mine is kept relatively free of dust, thus helping to maintain the health of the miners and to lessen the chances of an explosive mixture in the air.

U.S. Pat. No. 4,226,290 to L. H. McSweeney provides a detailed explanation of the  
20 devices and technique of "roof drilling" in coalmines and reference is made to that patent for a more complete explanation.

In the prior art, the hollow tubes, known as "drill steels" have been formed with flat surfaces, either square or hexagonal, at both ends. Such flat surfaces may be formed on the

external surface of the tube or the internal surface, and are used to connect one tube to another, to a drill chuck, or to a drill bit.

As explained in U.S. Pat. No. 4,226,290, the drill steels have different functions and are assigned different tasks. The drill steel may have a squared end or a "hands off" hexagonal end for engaging in the drive system. Various couplings and collars may be used and assembled by press fitting on the ends of the steels. Thus, a finisher is a rod having two hexagonal ends with one end engaging a drill bit while the other end fits into the female end of another length of drill steel called a pusher. The pusher, or another piece called a starter, may be engaged at one end in a drive system. A special purpose drill steel is also used to engage the roof bolt for insertion into the drilled hole.

In accordance with one conventional manufacturing technique, a drill steel section is cut to the desired drilling length for a particular member and then the ends of the section are typically beveled to facilitate welding of a component part onto the corresponding end of the drill steel section. Individual components are initially cast or otherwise fabricated by forging internal or external flat surfaces and then welded directly to an appropriate end of the corresponding drill steel section. Although such completed drill steel members, including the starter, driver, extension, and finisher, are generally easy to manufacture, many drawbacks for the manufacturing method exist.

First, such forging process has the adverse effect of causing a stressed, weakened portion to be created along the length of the drill steel adjacent to the forged surface. Additionally, the effects of heat produced during the welding of components to drill steel sections results in the production of stress fractures, cracks and other residual stresses as a result of the intense heating (welding temperatures can exceed hundreds of degrees of Fahrenheit) and cooling of the steel.

Fractures and cracks are produced not at the heat point but typically at the transfer points, or heat-affected zones, located on both sides of the heat point. Subsequent heat-treating does not completely cure the stressed and weakened area. Additionally, in the current industry, the joining of the components to the drill steel generally requires manual labor to assemble the parts.

5 This assembly process results in variability in alignment of the component parts to the drill sections, and thus in the alignment of one drill steel member, such as a driver, when joined to another drill steel member, such as a finisher.

As one skilled in the art will appreciate, the potential for misalignment as well as the production of stress fractures and cracks around the transfer point can lead to a premature failure  
10 of one or more of the drill steel members and thus result in unsafe working conditions. Once the drill member is inserted well within the depths of the drilling hole, the opportunity for lateral movement of the drill steel member within the hole is minimal. Since the drilling machine is stationary, any stresses or forces generated by misalignment of the drill steel members will be imparted on the weakest point of the drilling system, e.g., the existing stress fracture or crack or  
15 misaligned area, and thus the drill steel member will prematurely fail. Such a fracture gives rise to several problems.

The first of these is the great potential of injury to the miners operating the equipment or in the vicinity of the failure. Often fracture occurs in the area proximate the drive end of the drilling machine and near the drilling machine operator, an extremely hazardous and unsafe  
20 condition. The situation at the time of such a fracture may involve several lengths of hollow steel rods, perhaps 10 feet, or more, in length, extending vertically and pressed upwardly while being subjected to rotating forces and upward pressure. Consequently, a fracture of one section could cause a number of flying steel projectiles capable of causing injury.

Because such fractures are relatively common, to reduce the costs associated with this operation it has been the practice to repair the drill steel after it has fractured. This is done by cutting the steel to provide a clean smooth end and welding a new socket or flat surface shank on the now shortened length of drill steel. Apart from the time required for and expense of this process, the problem of the stressed portion following the now welded piece is created again because of the heat required for the welding operation and the possibility of new fractures, with all of the previous problems, still exists.

Another problem is the cost of time and energy to repair or replace the fractured piece in order that work may continue. Therefore, as one skilled in the art will appreciate, these problems result in higher production costs due to excessive component usage and equipment downtime.

Still a third problem is the uncertainty as to when the fracture will occur. This uncertainty exists because such failure may occur in a relatively short time after the drill steel is put into use or it may occur at any time and, therefore, all precautions taken for safety or other reasons must be available at all times.

As pointed out above, varying lengths of the hollow pieces of drill steel are connected one to the other to provide the necessary driving connection between the drill chuck and the drill bit. The bit cuttings and collected dust are drawn through the lengths of drill steel passing from one to the other until they are deposited in a collector. In the prior art where these lengths are connected to one another or other couplers, adapters, sockets or shanks, the ends of the various pieces are formed with flat surfaces. It is possible to have a build up of the collected material at these flat surfaces causing a narrowing flow area and perhaps causing a total stoppage of flow decreasing the efficiency of the system. This too can lead to a halt in the work, adding to the costs of operation.

After a hole has been drilled, the drill steel, as described herein, is removed, and a bolt is placed in the hole. Resin is then shot into the hole and the bolt is spun at a high rate until the resin is set, securing the bolt in the hole. The bolt is spun using a special purpose drill steel that incorporates an embodiment of this invention engaged at one end in the chuck of a rotating tool.

5 Thus, there has been a long felt need for an improved drill steel member that provides a longer product life and a significant reduction in premature failures during operation. Furthermore, there exists a long felt need for drill steel members that are not only safer for the mineworker and for the industry but also provide improved drilling performance.

### **SUMMARY OF THE INVENTION**

10 The present invention provides a family of drill steels for various purposes, including starters, drivers, finishers, and special purpose drill steels for turning roof bolts. The drill steel members disclosed herein do not utilize heat to join or configure component parts to the various sections.

It is, therefore, an object of the present invention to provide a strong, durable drill steel  
15 that avoids the disadvantages of the prior art.

It is another object of the present invention to provide a novel process for the manufacture of drill steels that does not result in a diminished strength area anywhere along the length of such an article. A related object of the present invention is to enable a drill steel that does not utilize heat to join or configure component parts to the ends of the drill steel sections.

20 It is another object of this invention to provide a novel drill steel capable of being used for extended periods with less concern for failure than heretofore possible.

A still further object of this invention is to provide a novel drill steel wherein the possibility of stoppage of flowing material within the steel is reduced.

In accordance with the above objects, a family of drill steels is disclosed which enables strong and durable drill steels manufactured by machining the ends of the drill steel, without the use of forging or welding. The drill steel comprises an elongate body having a uniform outer diameter with a generally hollow configuration and having each end of such body adapted for  
5 attaching additional components thereto, such ends being machined to a smaller outer diameter.

The foregoing and other objects of the invention are achieved by removing metal from the exterior or interior, as the case may be, of the hollow drill steel to form the required flat coupling or engaging surfaces. In a preferred embodiment, this is accomplished by machining the surfaces.

10 The various features of novelty that characterize the invention will be pointed out with particularity in the claims of this application.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

The above and other features, aspects, and advantages of the present invention are considered in more detail, in relation to the following description of embodiments thereof shown  
15 in the accompanying drawings, in which:

FIG. 1 is a side view partially in section illustrating one embodiment of the invention;

FIGS. 2 and 3 are end views along the lines 2--2 and 3--3 respectively of FIG. 1;

FIG. 4 is an exploded side view of another embodiment of the invention;

FIG. 5 is an end view along the line 5--5 of FIG. 4;

20 FIG. 6 is a partial side view of the end of a length of drill steel according the prior art;

FIG. 7 is a partial side view of the end of a length of drill steel in accordance with this invention;

FIG. 8 is an exploded view of one form of a special purpose drill steel embodying the invention; and

FIG. 9 is an exploded view of another form of a special purpose drill steel embodying the invention.

## **DETAILED DESCRIPTION OF THE INVENTION**

The invention summarized above and defined by the enumerated claims may be better understood by referring to the following description, which should be read in conjunction with the accompanying drawings in which like reference numbers are used for like parts. This description of an embodiment, set out below to enable one to build and use an implementation of the invention, is not intended to limit the enumerated claims, but to serve as a particular example thereof. Those skilled in the art should appreciate that they may readily use the conception and specific embodiment disclosed as a basis for modifying or designing other methods and systems for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent assemblies do not depart from the spirit and scope of the invention in its broadest form.

Referring first to Figure 1, reference numeral 2 designates generally a length of drill steel in the form of a tube having a hollow passage 4. Formed at one end is a first portion 6 having a hexagonal end. Such a hexagonal end is customarily used to engage a drill bit and may be provided with a hole 7 to engage a retaining clip. Formed at the other end is a second portion 8 having a hexagonal surface.

It should be understood, the shape of the flat surfaces on the ends of the drill steel is determined by the shape of the element with which it is to be connected, and therefore is typically shaped as a polygon, that is, square or hexagonal, as required. Thus, the coupling

element may be a socket for engaging another drill steel, a socket for engaging a roof bolt, a drill chuck, or a drill bit. In addition, the coupling element may be a collar or a shank permitting coupling to another member. Likewise, whether the flat surface is internal or external depends upon the same considerations. The various connectors, collars and such are provided with surfaces matching the end of the drill steel they are to engage and can be mounted on the steel using press fits.

Figures 2 and 3 illustrate the cross section of a drill steel section along the lines 2--2 and 3--3 respectively of Figure 1.

Figure 4 illustrates one embodiment of the invention. In this figure, the drill steel 9 has an external hexagonal surface 10 at one end for engaging a female connector 12 having an internal hexagonal surface 11 to attach another drill steel. See Figure 5, which is a sectional view along the lines 5--5 of Figure 4. Formed at the other end of drill steel 9 is a hexagonal external end 14 that may, when in use, engage in complementary tube 16 having a matching hexagonal internal surface that may be press fitted on the end 14 along with a collar 18.

As stated above, in the prior art the engaging square or hexagonal surfaces are formed by forging. In the forging process, the portion of the drill steel to be forged is heated to very high temperatures, approximately 1700 degrees F. and essentially beaten to the desired shape. This process results in a stressed and weakened portion in areas adjacent to the forged portion, such as indicated by the bracket 20 in Figure 1.

The present invention involves forming the flat surfaces by machining, that is, the necessary metal is removed from the drill steel, which consequently is not distorted by a forging process. This process is carried out using conventional machine tools such as a vertical mill. For example, hexagonal surfaces 10 and 14 are machined on drill steel 9. The drill steels

themselves are heat treated either prior or subsequent to the machining process. It should be understood that the temperatures used to heat treat are not the same magnitude as those used to render the steels malleable for forging.

As a result of this process, the drill steel is not weakened in any respect that we have been able to determine. Consequently, the possibility of fracture caused by a stressed section is lessened, if not eliminated entirely.

The resulting advantage to the industry and the miner has been pointed out above.

Reference is made to Figures 6 and 7 of the drawings for a description of another advantageous aspect of the invention. Figure 6 illustrates a drill steel 22 in accordance with the prior art. Drill steel 22 is shown broken to indicate it may be of any length. It is provided with two ends 24 and 26 having flat surfaces, each shown in cross section. The end 24 is formed as a square internal surface while the end 26 is formed as a hexagonal surface. In the prior art the respective faces 28 and 30 of each of these flat surfaces are at right angles to their lengthwise extensions. Thus, as material from the drill bit flows through the drill steel when in operation such material may collect around the flat surfaces, such as faces 28 and 30. The build up of such material can result in blockage or narrowing of the passage thereby decreasing the efficiency of the process.

By machining the flat surfaces in accordance with the invention, the ends or faces can be chamfered or sloped as shown at 32 and 34 in Figure 7. In this figure, the drill steel 36 is shown as having an exterior hexagonal surface 38 and an interior square surface 40. As the result of this construction, no sharp ledges or faces, such as shown at 28 and 30 in Figure 6, are presented to obstruct the flow of materials.

As stated above, the invention may be used to make drill steels to secure bolts in the holes formed by drilling using drill steels incorporating the invention. Such drill steels also are made by machining or otherwise removing metal from the surfaces of steel or alloy pieces.

Thus, in Figure 8, drill steel 49 comprises a head 50 having a hexagonal or square recess  
5 on one end forming a socket to engage a roof bolt. The other end of head 50 is formed with an extension having a machined interior surface 52, having a uniform interior diameter. A body 54 is likewise formed from an elongate tube with machined surfaces on two male ends of body 54. At a first male end, machined surface 56 is shaped to match interior surface 52. Machined surface 56 has a uniform outer diameter that is slightly larger than the inner diameter of  
10 machined interior surface 52. Body 54 is connected to head 50 by matching the first male end shaped machined surface 56 with the shaped interior surface 52 and press fitting the components together. At the second male end of body 54, machined surface 58 is shaped having a uniform outer diameter that is smaller than the outer diameter of body 54. The shape of machined surface 58 may be hexagonal or square in order to engage the drive chuck of the roof-drilling machine or  
15 other drill. As may be seen, in accordance with current practice machined surface 58 is generally longer than machined surface 56 to facilitate coupling to a drill chuck. Drill steel 49 further comprises a collar 60 having an aperture therethrough, shaped to match machined surface 58. The inner diameter of such aperture is slightly smaller than the uniform outer diameter of machined surface 58. Collar 60 is press-fit onto machined surface 58 until collar 60 engages  
20 shoulder 61. Shoulder 61 is formed on body 54 during machining of machined surface 58 since the outer diameter of machined surface 58 is smaller than the outer diameter of body 54. Collar 60 limits the insertion of machined surface 58 into the drill chuck. The drill steel thus formed uses no forging or welding with attendant weakened zones.

In Figure 9, an alternate embodiment of a drill steel is provided. Drill steel 62 comprises a head 63 having a first recess forming a socket to engage a roof bolt, a body 64 having a generally uniform exterior diameter with two male end machined surfaces 66 and 68, and a chuck-engaging piece 70 with surfaces machined to engage the body 64 and the drill chuck.

5        Head 63 further comprises an extension having a second machined recess, having a uniform interior diameter. Machined surface 66 is configured to match such second machined recess in head 63. Machined surface 66 has a uniform outer diameter that is smaller than the exterior diameter of body 64 and slightly larger than the inner diameter of the second machined recess in head 63. In a preferred embodiment, the socket in head 63 is configured to engage a  
10    square roof bolt; both recesses in head 63 and machined surface 66 are also shaped as a square in cross-section. Body 64 is connected to head 63 by matching the shaped machined surface 66 with the second shaped machined recess and press fitting the components together.

      Body 64 further comprises machined surface 68 having a uniform exterior diameter slightly smaller than body 64. The shape of machined surface 68 may be configured as  
15    hexagonal or square in cross-section in order to be connected to chuck engaging piece 70. Chuck engaging piece 70 comprises a machined recess configured in the same shape as machined surface 68. Chuck engaging piece 70 is press-fit onto machined surface 68. The exterior surface of engaging piece 70 is machined to an appropriate shape, such as square or hexagonal, to engage a drill chuck. A chuck insertion limiting shoulder 72 is machined into the  
20    structure of engaging piece 70. Shoulder 72 is designed to limit the depth to which drill steel 62 can be inserted into the drill chuck. After machining, these parts are pressed onto each other to complete drill steel 62. Again, there are no forged or welded parts.

It should be understood that the process of machining drill steel can be used on any such devices whether it be a starter, a pusher, a finisher, or a driver. Likewise the process can be used on the chucks, adaptors, shanks, couplings and the like, that are formed with square or hexagonal surfaces used with drill steels.

5           The invention has been described with references to a preferred embodiment. While specific values, relationships, materials and steps for various embodiments have been set forth for purposes of describing concepts of the invention, it will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the basic concepts and  
10   operating principles of the invention as broadly described. It should be recognized that, in the light of the above teachings, those skilled in the art can modify those specifics without departing from the invention taught herein. Having now fully set forth the preferred embodiments and certain modifications of the concept underlying the present invention, various other embodiments as well as certain variations and modifications of the embodiments herein shown and described  
15   will obviously occur to those skilled in the art upon becoming familiar with said underlying concept. It is contemplated to include all such embodiments, alternatives and other modifications insofar as they come within the scope of the claims appended hereto or equivalents thereof. It should be understood, therefore, that the invention may be practiced otherwise than as specifically set forth herein. Consequently, the present embodiments are to be considered in all  
20   respects as illustrative and not restrictive.